Test Report # 319220 B

Equipment Under Test:	BL654 Series
Test Date(s):	12/11/20
Prepared for:	ATTN: Jonathan Kaye Laird Connectivity W66 N220 Commerce Ct. Cedarburg, WI 53012

Report Issued by: Shane Dock, EMC Engineer

Signature:

Date: 1/12/2021

Report Reviewed by: Adam Alger, Quality Manager

Signature:

Date: 01/12/2021

Report Constructed by: Shane Dock, EMC Engineer

Signature:

Date: 12/11/2020

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Laird Connectivity Test Services in Review

The Laird Connectivity, Inc. laboratory located at W66 N220 Commerce Court Cedarburg, Wisconsin, 53012 USA is recognized through the following organizations:

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025:2017 with Electrical (EMC) Scope

A2LA Certificate Number: 1255.01

Scope of accreditation includes all test methods listed herein unless otherwise noted

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Federal Communications Commission (FCC) – USA

Accredited Test Firm Registration Number: 953492

Recognition of two 3 meter Semi-Anechoic Chambers

Government of Canada

Innovation, Science and Economic Development Canada

Accredited U.S. Identification Number: US0218

Recognition of two 3 meter Semi-Anechoic Chambers

1 Test Report Summary

During **9/15/20** the Equipment Under Test (EUT), **BL654 Series**, as provided by **Laird Connectivity** was tested to the following requirements:

Requirement	Description	Specification	Method	Result
FCC Part 1.1307, 2.1091, 2.1093	RF Exposure and equipment authorization requirements	Reported	FCC KDB 447498	Reported
ISED Canada RSS-102	Radiofrequency Radiation Exposure Evaluation: Portable	Reported	RSS-102 Section 2.5.2	Reported

Notice:

The results relate only to the item tested as configured and described in this report. Any additional configurations, modes of operation, or modifications made to the equipment under test after the specified test date(s) are at the decision of the client and may not apply to the data seen in this test report.

The decision rule for Pass / Fail assessment to the specification or standard listed in this test report has been agreed upon by the client and laboratory to be as follows:

Measurement Type	Rule
Emissions – Amplitude	2 dB below specified limit
Emissions – Frequency	1% less than the specification
Immunity	Tested at specified level

2 CLIENT INFORMATION

Company Name	Laird Connectivity
Contact Person	Jonathan Kaye
Address	W66N220 Commerce Court Cedarburg, WI 53086

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	BL654 Series
Model Number	BL654 Series
Serial Number	180916101621 180523200079 180927206472
FCC/IC ID's	FCC: SQGBL654 IC: 3147A-BL654

2.2 Product Description

802.15.4 Data Module

2.3 Modifications Incorporated for Compliance

None noted at time of test

2.4 Deviations and Exclusions from Test Specifications

None noted at time of test

2.5 Additional Information

The EUT is a devkit for a BL654 powered by 3 AAA batteries and programmed via serial connection program (PuTTy). The original filing did not include the proprietary 802.15.4 radio, and this testing is pursuant to a permissive change to add this to the filing. The EUT was tested on channels 11, 18, 25, and 26 with the cabinet radiation method, with a maximum antenna gain of 2.0 dBi. From here, 11, 18, and 25 are referred to as the low mid, and high channels of the full power channels. Power settings tested for each channel are included below.

- Low, Mid, High Channel: -40 dBm, 8 dBm
- Channel 26: -40 dBm, -8 dBm

3 REFERENCES

Publication	Edition	Date
CFR 47 Part 15	-	2020
ANSI C63.10	-	2013
RSS-247	2	2017
RSS GEN	5	2014
RSS-102	5	2015
CFR 47 Part 1 and 2	-	2018
FCC KDB 447498	6	2015

4 Uncertainty Summary

Using the guidance of the following publications the calculated measurement uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k = 2.

References	Version / Date
CISPR 16-4-1	Ed. 2 (2009-02)
CISPR 16-4-2	Ed. 2 (2011-06)
CISPR 32	Ed. 1 (2012-01)
ANSI C63.23	2012
A2LA P103	February 4, 2016
A2LA P103c	August 10, 2015
ETSI TR 100-028	V1.3.1 (2001-03)

Measurement Type	Configuration	Uncertainty ±
Radiated Emissions	Biconical Antenna	5.0 dB
Radiated Emissions	Log Periodic Antenna	5.3 dB
Radiated Emissions	Horn Antenna	4.7 dB
AC Line Conducted Emissions	Artificial Mains Network	3.4 dB
Telecom Conducted Emissions	Asymmetric Artificial Network	4.9 dB
Disturbance Power Emissions	Absorbing Clamp	4.1 dB
Radiated Immunity	3 Volts/meter	2.2 dB
Conducted Immunity	CDN/EM/BCI	2.4/3.5/3.4 dB
EFT Burst/Surge	Peak pulse voltage	164 volts
ESD Immunity	15 kV level	1377 Volts

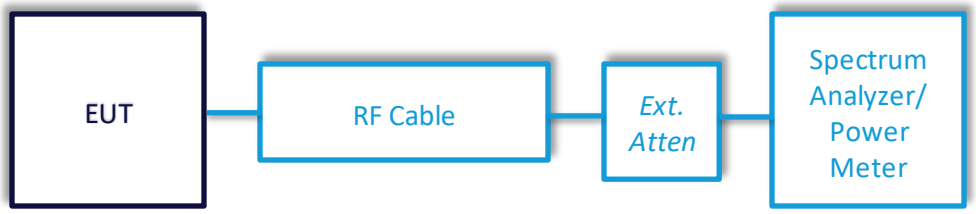
Parameter	ETSI U.C. ±	U.C. ±
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %

5 TEST DATA

5.1 Antenna Port Conducted Emissions

Description of Measurement	The direct measurement of emissions at the antenna port of the EUT is achieved by use of a RF connection to a spectrum analyzer or power meter. The cable and attenuator factors are loaded into the analyzer or power meter allowing for direct measurement readings without the need for further corrections.
Example Calculations	Measurement (dBm) + Cable factor (dB) + External Attenuator (dB) = Corrected Reading (dBm) Margin (dB) = Limit (dBm) – Corrected Reading (dBm)

Block Diagram



5.1.1 Antenna Port Conducted Emissions

Operator	Jon Dilley	QA	Shane Dock
Temperature	23.9 degrees Celsius	R.H. %	18.5% RH
Test Date	1/20/2020	Location	Conducted Bench
Requirement	FCC 15.247	Method	ANSI C63.10

Limits:

Pout: 30 dBm

Instrumentation

Date : 10-Aug-2020 Test : FCC Tx Job : C-3290

PE : Shane Dock Customer : Laird Connectivity Quote : 319220

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	AA 960143	Cable	Gore	EKD01D01048.0	5546519	12/9/2019	1/9/2021	Active Calibration
2	EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	7/14/2020	7/14/2021	Active Calibration

EUT Parameters

Input Power	Battery Powered	Mode	Modulated Tx
Frequency	2400-2483.5 MHz	Channel	Low, Mid, High

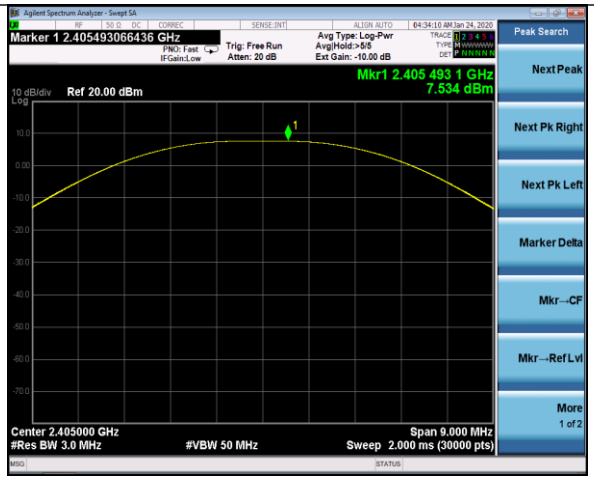
Data

Table – Output Power

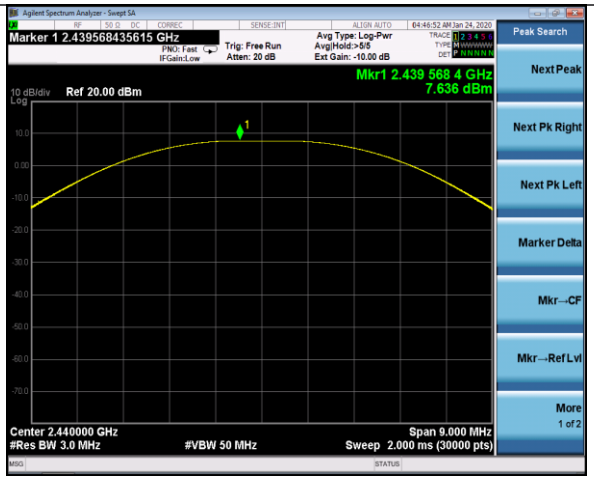
Channel	Power Setting (dBm)	Pout Measured (dBm)
11	8	7.5
11	-40	-35.9
18	8	7.6
18	-40	-35.9
25	8	7.7
25	-40	-35.9
26	-8	-6.6
26	-40	-36.1

Worst Case Plots – 8 dBm

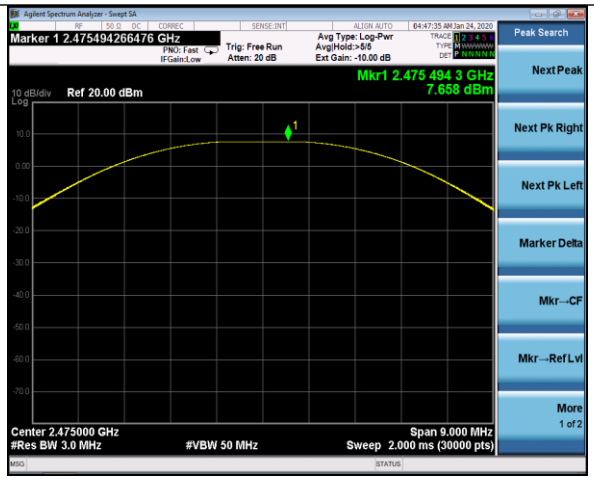
Conducted Output Power



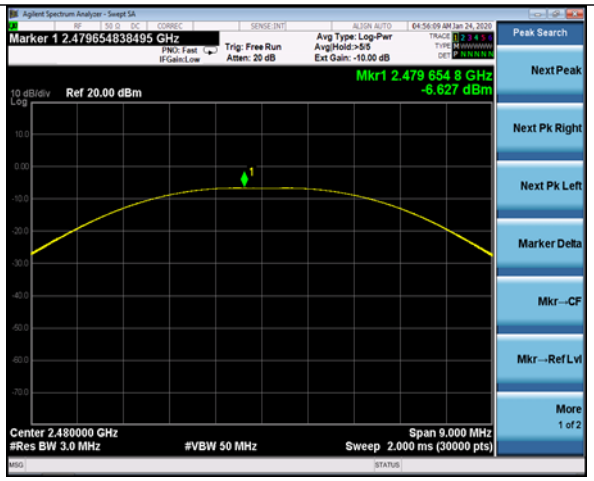
Low Channel



Mid Channel



High Channel



Channel 26

6 EXCLUSION CALCULATION

6.1 FCC

Worst Case Scenario: 7.7 dBm at 2475 MHz
Tune-Up Tolerance: 2.0 dB
Total Power: 9.7 dBm = 9.3 mW
Peak Antenna Gain: 2.0 dBi
Minimum test separation distance: To be calculated (EUT is a module).

From OET KDB 447498 Section 4.3.1.a:

For 100 MHz to 6 GHz and *test separation distances* ≤ 50 mm, the 1-g and 10-g *SAR test exclusion thresholds* are determined by the following:

[(*max. power of channel, including tune-up tolerance, mW*) / (*min. test separation distance, mm*)] · [$\sqrt{f_{(GHz)}}$] ≤ 3.0 for 1-g SAR, and ≤ 7.5 for 10-g extremity SAR,[30] where

- $f_{(GHz)}$ is the RF channel transmit frequency in GHz

(9.3 mW / X mm) * sqrt(2.475 GHz) <= 3.0

Minimum test separation distance = 5 mm

At 5 mm, the EUT is exempt from routine evaluation as:

(9.3 mW / 5 mm) * sqrt(2.475 GHz) = 2.9, which is less than 3.0.

6.2 ISED Canada

Per Section 2.5.1:

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance[4,5]

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

Exemption limit at 10 mm for 2475 MHz (interpolated): 7 mW
Exemption limit at 15 mm for 2475 MHz (interpolated): 15 mW

Since 9.3 mW is above the 10 mm limit but not the 15 mm limit, the EUT is exempt from routine for all test separation distances at 15 mm or greater.

7 REVISION HISTORY

Version	Date	Notes	Person
0	12/11/20	First Draft	Shane Dock
1	1/12/21	Updated Draft	Shane Dock
2	1/12/21	Final Draft	Shane Dock

END OF REPORT